MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EMF3046 – RF MEASUREMENT TECHNIQUES

(TE)

18 OCTOBER 2018
2.30 P.M - 4.30 P.M.
(2 Hours)

INSTRUCTION TO STUDENT

1. This Question paper consists of 6 pages with 4 Questions only.

2. Answer all **FOUR (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

a) List TWO (2) advantages of using decibel (dB) scale in RF/Microwave power measurements.

[8 Marks]

b) An RF signal with input power (P_{in}) of 10 dBm and frequency (F_{RF}) of 900 MHz is connected to a receiver front-end shown in Figure Q1, with the given insertion loss (IL) of the filters, gain (G) of the amplifier and conversion gain (CG) of the mixer.

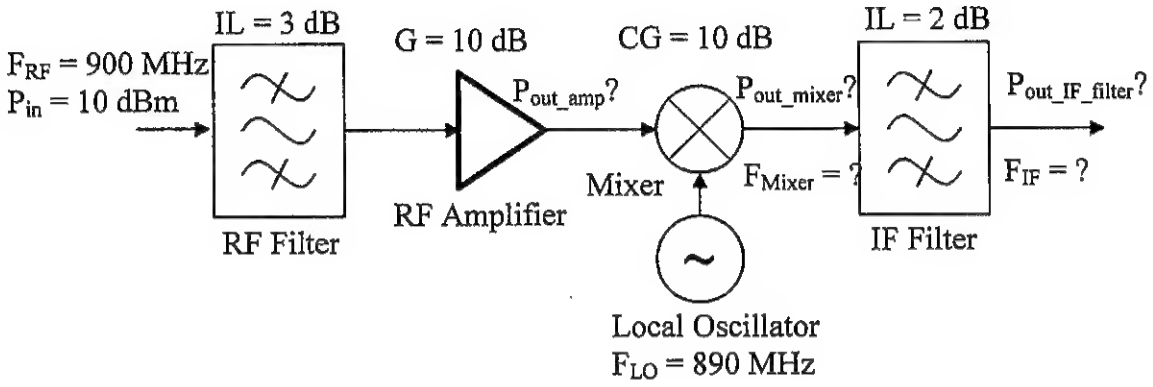


Figure Q1

i) Briefly explain the usages of RF and IF filters used in this receiver.

[4 Marks]

ii) Determine the overall gain of this receiver (in both normal and dB scale) and its respective image frequency.

[4 Marks]

iii) Determine the RF power that will be measured at the RF amplifier output (P_{out_amp}, in mW).

[2 Marks]

iv) List all the possible frequencies appeared after the mixer. Next, determine the down-converted IF frequency, F_{IF}.

[3 Marks]

v) Determine the IF power that will be measured at the mixer output (P_{out_mixer}, in mW).

[2 Marks]

vi) Determine the IF power that will be measured at IF filter output ($P_{out\_IF\_filter}$, in mW).

[2 Marks]

Continued...

Question 2

a) Explain the principle of operation for a swept-tuned spectrum analyzer using a block diagram.

[9 Marks]

b) A coaxial filter is connected in between the multi-tone signal generator and spectrum analyzer as shown below in Figure Q2.
(Assume that the connecting cables and connectors have no loss)

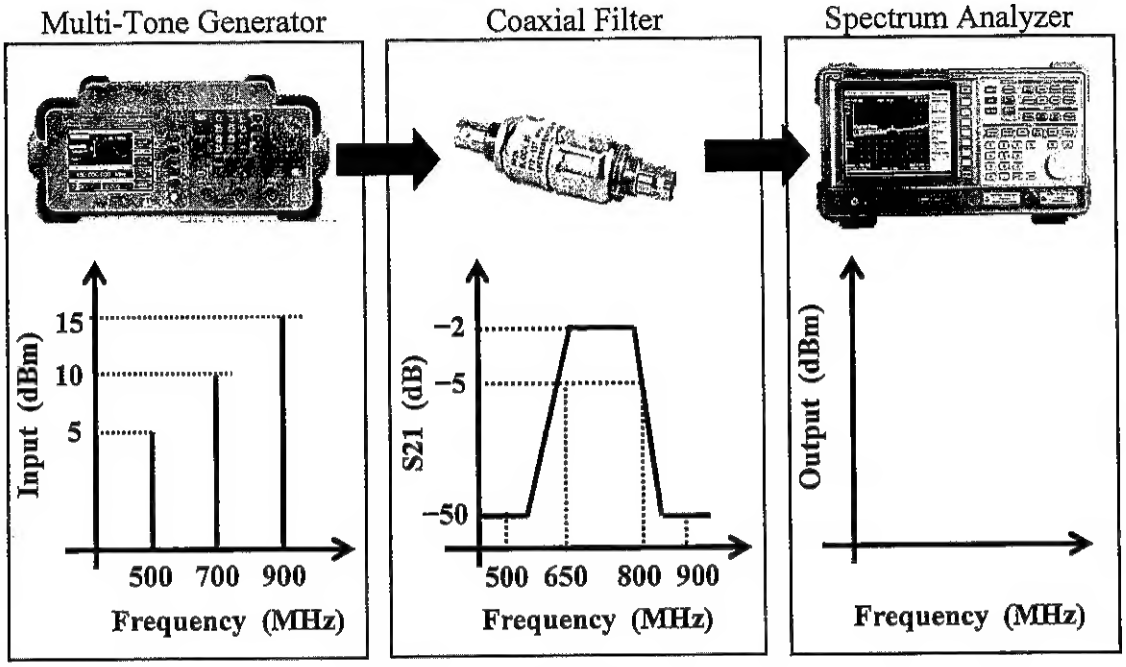


Figure Q2

i) What type of filter is shown in the above measurement?

[1 Mark]

ii) Briefly explain TWO (2) functions of filter used in RF applications.

[4 Marks]

iii) Determine the insertion loss, cut-off frequencies, center frequency and 3 dB bandwidth of the filter.

[4 Marks]

iv) What are the stop-band frequencies and rejections of the filter?

[4 Marks]

v) Sketch the output of the spectrum analyzer in the graph above, indicating the frequency points and power level.

[3 Marks]

Continued...

Question 3

a) Explain briefly THREE (3) errors occurred in a typical vector network analyzer measurement.

[6 Marks]

b) A device under test (DUT) has the following *S*-parameters (in touchstone or S2P file format) before and after the 2-port Short-Open-Load-Thru (SOLT) calibration, as shown in Figure Q3.

```
! Un-calibrated
! S11  S21  S12  S22
# GHZ S MA R 50
 .100 1.000 -10.5 9.271 172.8 .014 83.1 .830 -6.9
 .200  .983 -20.2 9.176 165.5 .027 76.6 .825 -13.8
 .300  .977 -31.4 8.885 158.5 .040 70.7 .803 -20.1
 .400  .964 -41.1 8.652 151.9 .051 65.1 .784 -26.3
 .500  .928 -50.4 8.301 144.4 .061 58.6 .745 -32.7
 .600  .907 -59.3 7.956 138.5 .071 53.8 .722 -37.9
 .700  .885 -67.6 7.607 132.8 .078 49.2 .691 -43.2
 .800  .864 -75.3 7.262 127.6 .085 44.9 .665 -47.9
 .900  .847 -82.6 6.904 122.6 .091 41.0 .641 -51.8
1.000  .828 -89.2 6.591 117.9 .096 37.5 .614 -55.8
```

```
! SOLT calibrated
! S11  S21  S12  S22
# GHZ S MA R 50
 .100  .100 -80.5 12.27 122.8 .004 83.1 .130 -6.9
 .200  .183 -90.2 12.17 125.5 .017 76.6 .125 -3.8
 .300  .177 -91.4 11.85 138.5 .020 70.7 .103 -5.1
 .400  .164 -91.1 11.62 161.9 .011 65.1 .084  6.3
 .500  .128 -90.4 11.30 184.4 .031 58.6 .045  2.7
 .600  .090 -99.3 10.56 118.5 .011 53.8 .022  3.9
 .700  .085  67.6 10.67 152.8 .018 49.2 .091  4.2
 .800  .064  25.3 10.62 117.6 .025 44.9 .065  4.9
 .900  .047   2.6 10.04 112.6 .011 41.0 .041  5.8
1.000  .028   0.0 10.91 107.9 .016 37.5 .014  0.0
```

Figure Q3

i) Explain briefly TWO (2) advantages of 2-port SOLT calibration.

[4 Marks]

ii) List THREE (3) errors removed by 2-port SOLT calibration.

[3 Marks]

iii) Determine the frequency range and reference impedance used in the above measurements.

[2 Marks]

iv) Determine the input impedance (Z_{in}) and output impedance (Z_{out}) of the DUT before and after performing the calibration at 1 GHz.

[2 Marks]

v) Are the input and output of the DUT matched to reference impedance, after performing the 2-port SOLT calibration at 1 GHz? Justify your answer.

[2 Marks]

vi) Determine the input and output return losses of the DUT before and after performing the calibrations at 1 GHz.

[2 Marks]

vii) Is the above DUT has power gain or power loss at 1 GHz? Justify your answer.

[2 Marks]

viii) What is the power gain or power loss of the above DUT in dB at 1 GHz?

[1 Mark]

ix) What is the isolation the above DUT in dB at 1 GHz?

[1 Mark]

Continued...

Question 4

a) A low noise amplifier with noise figure of 3 dB and power gain of 10 dB is connected to the input of a filter with insertion loss of 2 dB and then followed by an amplifier with noise figure of 5 dB and power gain of 20 dB (as shown in Figure Q4a). Determine the total power gain (in absolute unit and decibel, dB), noise factor and noise figure contributed by this system.

[7 Marks]

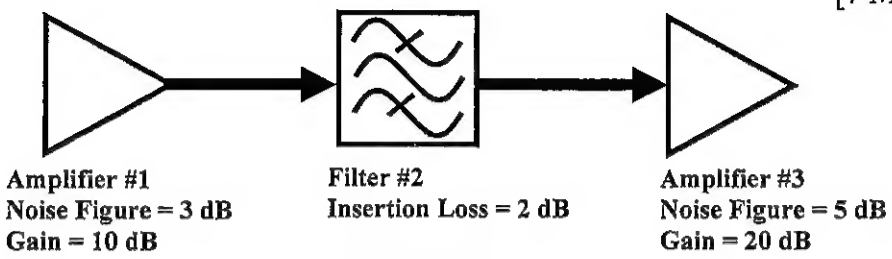
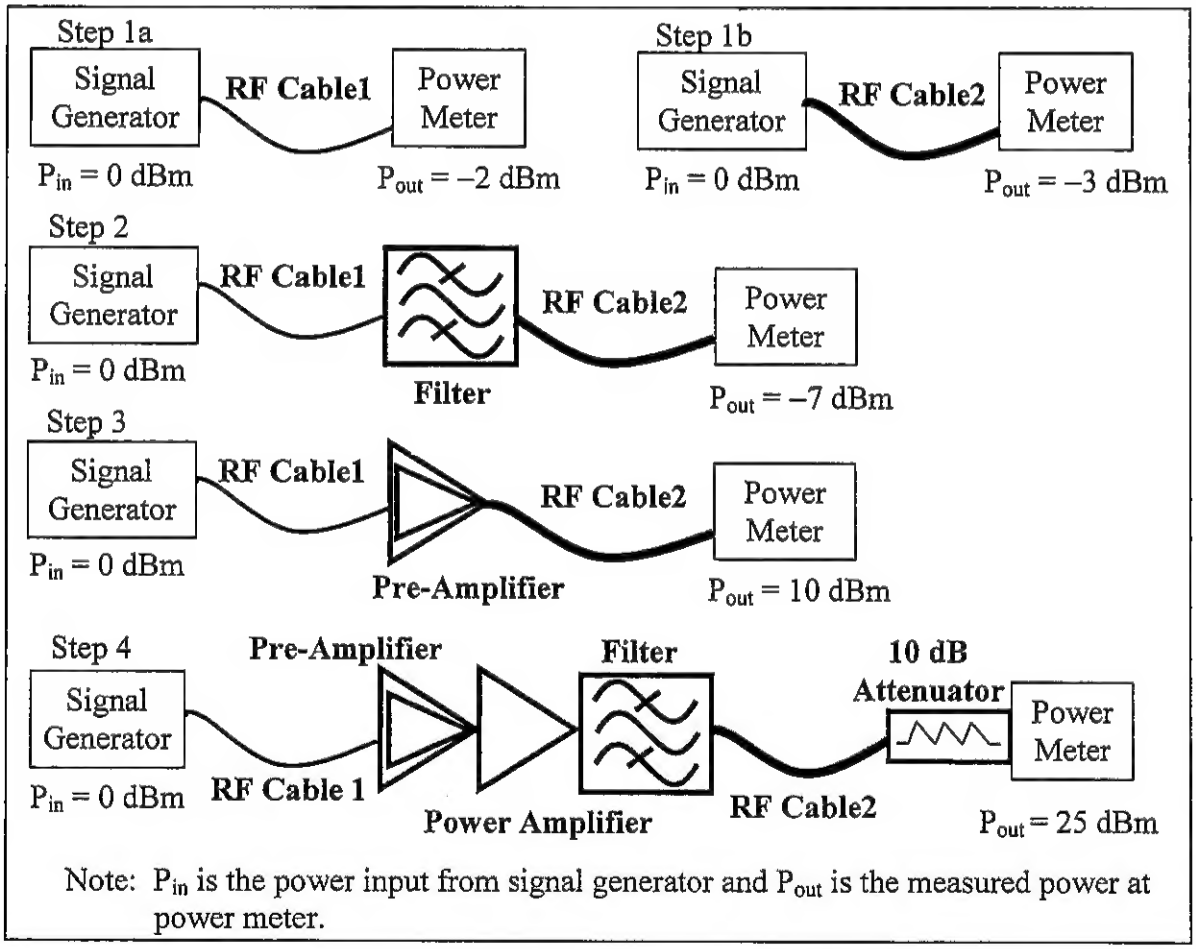


Figure Q4a

b) The procedures of measuring gain for a power amplifier with filter, pre-amplifier and radio frequency (RF) cables are illustrated below (Figure Q4b) :



Note: P_{in} is the power input from signal generator and P_{out} is the measured power at power meter.

Figure Q4b

Continued...

i) Explain briefly THREE (3) characteristics of an RF Power amplifier
[6 Marks]

ii) Explain briefly the function of filter in the above measurement.
[2 Marks]

iii) Explain briefly the function of pre-amplifier in the above measurement.
[2 Marks]

iv) Explain briefly the function of attenuator in the above measurement.
[2 Marks]

v) What are the power losses contributed by the RF Cable1 and RF Cable2?
[2 Marks]

vi) Determine the insertion loss of the filter.
[2 Marks]

vii) Determine the gain of the power-amplifier.
[2 Marks]

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